TWO *OSMUNDOPSIS* SPECIES AND THEIR STERILE FOLIAGE FROM THE MIDDLE JURASSIC OF YORKSHIRE

by JOHANNA H. A. VAN KONIJNENBURG-VAN CITTERT

ABSTRACT. *Osmundopsis hillii* sp. nov., from Hasty Bank, Yorkshire, is probably the fertile foliage of *Cladophlebis harrisii*. New material of *Osmundopsis sturii* from Gristhorpe suggests that it might be the fertile foliage of part of *Cladophlebis denticulata*. Sterile foliage that was provisionally assigned to *O. sturii* is probably a large form of *Eboracia lobifolia*.

HARRIS (1931) established the genus *Osmundopsis* for fertile osmundaceous remains in which no lamina is present in the pinnules, and the sporangia are arranged in clusters as in the extant genus *Osmunda*. The type species is *Osmundopsis sturii* (Raciborski) Harris (basionym *Osmunda sturii* Raciborski, 1890) known from the Upper Liassic of Poland (Raciborski 1890; Harris 1977) and Iran (Schweitzer *et al.* in press), and the Middle Jurassic of Yorkshire (Harris 1961, 1977), Abchasia (Krystofovich and Prynada 1933) and China (Duan 1987). Several other species have been found in Mesozoic strata including the well-known *O. plectrophora* from the Liassic of Greenland (Harris 1931).

Over several years, Dr C. R. Hill (London, UK) collected fertile *Osmundopsis* material at Hasty Bank, Yorkshire. He prepared the material, made photographs and isolated some spores from one of the specimens (the slide with these spores was damaged beyond repair in the mail when the present author, who studied these spores, returned it to him). This *Osmundopsis* material (including some newly isolated spores) is described here as a new species which I name after Dr Hill in honour of the work he did on the Yorkshire Jurassic flora, especially that of Hasty Bank. *Cladophlebis harrisii* van Cittert, 1966 is very probably the sterile foliage belonging to *Osmundopsis hillii*.

Dr J. Lovis (formerly Leeds, UK, now Christchurch, New Zealand) had a large collection of Yorkshire Jurassic material which he presented to The Natural History Museum, London on leaving England. This collection includes several specimens of *Osmundopsis sturii* which extend our knowledge of this species. A new specimen of *O. sturii* in the Utrecht collection (the Netherlands) is also included in the description. The study also includes sterile foliage that Lovis thought might belong to *O. sturii*. Although it was first thought to be a new species, it proved to be merely a large form of *Eboracia lobifolia* (Dicksoniaceae). Some of the smaller specimens of this sterile material showed all the features characteristic of *E. lobifolia* (including the typical forked basal pinnule) and transitional specimens are also present. The sterile foliage belonging to *O. sturii* is still a problem, but might well be a small form of *Cladophlebis denticulata*.

MATERIAL AND METHODS

The material of *Osmundopsis hillii* was collected by Dr C. R. Hill at Hasty Bank, Yorkshire [NZ 568035], especially from the claystone layer in the lower part of the plant bed (see Hill and van Konijnenburg-van Cittert 1973). This plant bed is in the Saltwick Formation (Aalenian). Most of the *Osmundopsis sturii* material was collected by Dr J. Lovis from the main Gristhorpe plant bed at Cayton Bay (near Scarborough; TA 083842), where the Utrecht specimen was also found. One specimen was found at the Cloughton Wyke *Solenites*-bed [TA 020951]. Both these localities belong to the Cloughton Formation, Gristhorpe Member (Lower Bajocian). For a summary of the geology of the Yorkshire Jurassic, see Hemingway and Knox (1973).

Spores were recovered from the material by selecting (if possible) one sporangium of each taxon, macerating it in Schulze's reagent, and neutralizing with ammonia. For light microscopy, macerated fossil spores were mounted in glycerine jelly and sealed with paraffin wax. The slides were examined with a Leitz Ortholux microscope. For scanning electron microscopy (SEM), the samples were dehydrated in a graded ethanol and acetone series, placed on a standard specimen stub and air dried. They were coated with gold, and both viewed and photographed with a Camscan.

Most of the material is kept at The Natural History Museum, London (prefix V). One specimen is kept at the Laboratory of Palaeobotany and Palynology, University of Utrecht, the Netherlands (prefix S).

SYSTEMATIC PALAEONTOLOGY

Genus OSMUNDOPSIS Harris, 1931

Osmundopsis hillii sp. nov.

Plate 1, figures 1–5; Plate 4, figures 1, 6–7

Derivation of name. After Dr C. R. Hill who collected the material.

Holotype. V.60952 (Pl. 1, fig. 1); V.60953 (Pl. 1, fig. 2) is its counterpart; from Hasty Bank, Yorkshire, England; Saltwick Formation (Aalenian).

Diagnosis. Fertile leaf or leaf fragment with a slender, longitudinally striated rachis bearing widely spread subopposite branches arising at a wide angle. Branches probably equivalent of pinnules. 'Pinnules' up to 5 mm long, 1·5 mm wide, consisting of a narrow midrib bearing alternate, minute protuberances, each covered with a group of up to eight sporangia. Sporangia pyriform or obovate, 400–500 μm × 200–300 μm. Cells of apical region thickened, vertical dehiscence slit. Spores trilete, globose; exospore granulate; granules *c.* 1 μm in diameter; triradiate scar distinct, long without a margo. Mean spore diameter 42 μm (measured range 36–45 μm).

Description. The holotype (V.60952; Pl. 1, fig. 1) shows a 40 mm long leaf fragment. Its 0·7 mm wide, longitudinally striated rachis bears subopposite 'pinnules', six on each side, arising at an angle of 70–85°. The pinnules are *c.* 5 mm apart. It is probably an apical fragment, as the angle at which the pinnules arise is larger basally than apically, and because the lower pinnules are larger (5 mm × 1·5 mm) than the upper ones (3 × 1·2 mm). The pinnules consist of a slender (0·1 mm wide) midrib bearing very short, alternate axes covered with up to eight sporangia. There are four groups of sporangia on each side of the midrib in the lower pinnules, three groups in the upper ones. The first group arises at the basiscopic side. The groups of sporangia are *c.* 0·8 mm wide; each sporangium being *c.* 0·4 mm long and 0·3 mm wide. Only one spore (44 μm in diameter; Pl. 4, fig. 6) has been recovered as the sporangia had all shed their spores.

The counterpart (V.60953) shows a smaller part of the leaf fragment (only the apical part) but with an extra apical 5 mm including an extra, small cluster of sporangia on one side of the rachis (Pl. 1, fig. 2).

V.60954 and V.60955 (Pl. 1, fig. 3) are part and counterpart of a 15 mm long fragment. Its 0·8 mm wide, longitudinally striated rachis bears three pairs of subopposite to almost alternate pinnules, arising at an angle

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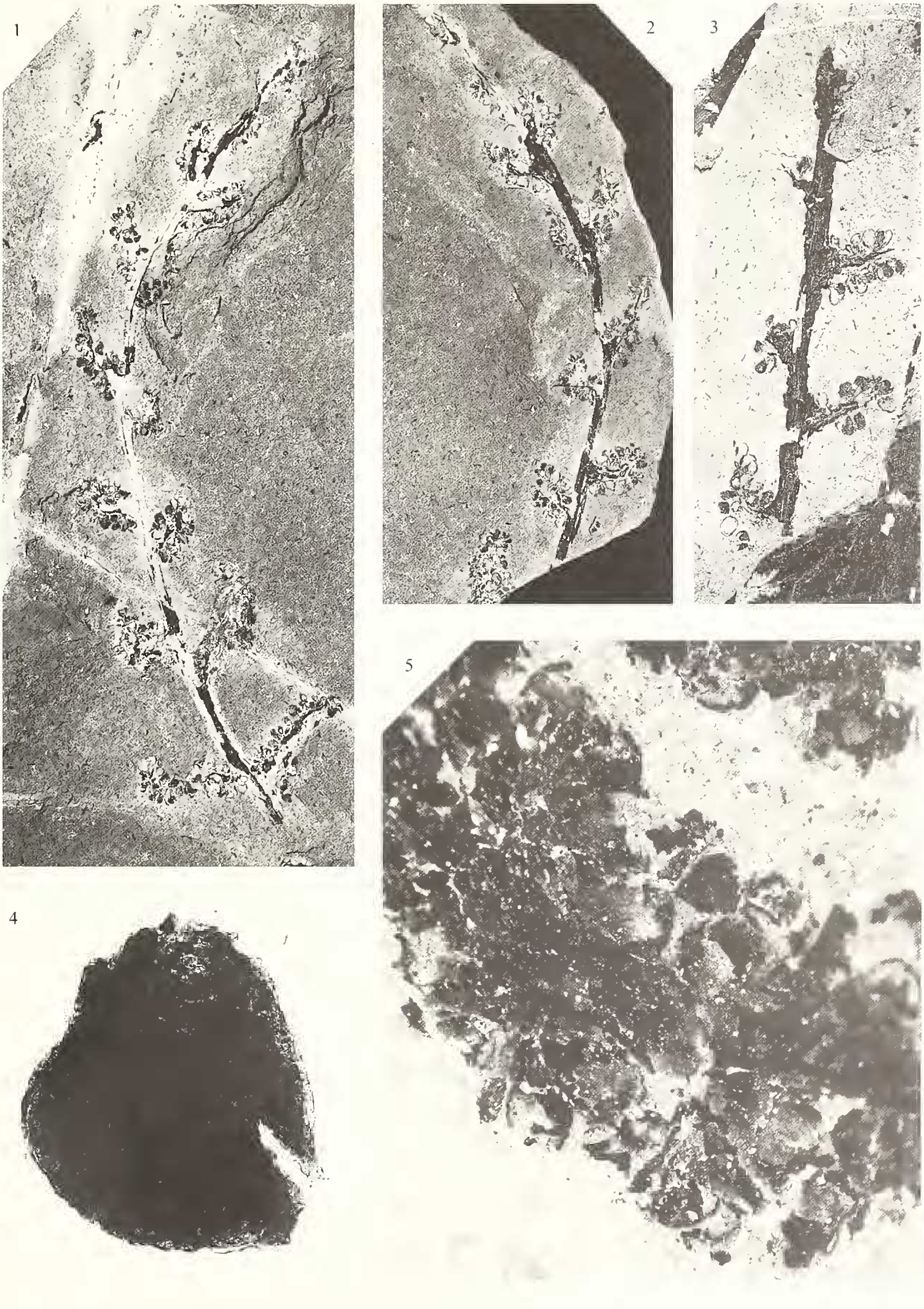
EXPLANATION OF PLATE 1

Figs 1–5. *Osmundopsis hillii* sp. nov. 1, holotype, V.60952; ×3. 2, counterpart of holotype, V.60953; ×3. 3, V.60955; ×5. 4, sporangium showing dehiscence slit, V.60954$1; ×150. 5, epoxy transfer V.60967, showing sporangia; ×30.

Figs 1–3 and 5, photographs courtesy of Dr C. R. Hill.

PLATE 1



VAN KONIJNENBURG-VAN CITTERT, *Osmundopsis* of *c.* 70° and *c.* 4 mm apart. The incomplete 'pinnules' (the apical parts are missing) are 2·5 mm long and 1·5 mm wide; their slender midrib bears three clusters of sporangia on each side. The sporangia are 400–500 μm long and up to 300 μm wide. Some show thickened apical cells and a vertical dehiscence slit (Pl. 1, fig. 4). Although these sporangia had also shed their spores, several spores were found sticking to the sporangial walls. They are included in the spore description. Spores were only studied under light microscopy (Pl. 4, figs 1, 7), and so it was impossible to see if the granules were fused in an irregular pattern as in *O. sturii.*

V.60956 shows a 25 mm long fragment, closely associated with sterile foliage of *Cladophlebis harrisii.* The 0·8 mm wide, longitudinally striated rachis is covered with seven pairs of almost opposite pinnules, arising at 80–90°, only 2–3 mm apart. The pinnules are *c.* 3 mm long and 1·2–1·5 mm wide and consist of a slender midrib with three alternate clusters of sporangia (first one on basiscopic side). The sporangia are 500 × 300 μm. Again only a few spores could be recovered.

V.60967 is an epoxy resin transfer of one pinnule, 3 mm long, 1·2 mm wide, showing three clusters of sporangia on each side. This specimen demonstrates the apically thickened cells and the vertical dehiscence slit (Pl. 1, fig. 5).

Remarks. Although only a few specimens are present, the material differs so much from any known species of *Osmundopsis* that it is necessary to describe it as a new species. The main differences from other, well-known species are the small size of the 'pinnules', only up to 5 mm long (for instance, *Osmundopsis sturii* and *O. plectrophora*, such as from the Liassic of Greenland, have pinnules that are over 10 mm long) and the greater distance between the pinnules (see Table 1). In *O. hillii* there is always some distance between the pinnules, while in the other two species they can be almost in contact. Finally, the size of the sporangia in *O. hillii* is significantly smaller than in the other species (only 500 μm long, *versus* up to 800 μm in the other species). The differences from other *Osmundopsis* species are discussed below under *O. sturii.* For comparisons see also Table 1.

Sterile foliage. On V.60956, *O. hillii* is closely associated with *Cladophlebis harrisii* van Cittert, 1966 (this species was mistakenly described in Harris (1961) as *Selenocarpus muensterianus*). This sterile foliage is also present on the holotype, together with other fossils, such as the conifer *Elatides thomasii* and the dicksoniaceous fern *Dicksonia mariopteris*, the fertile foliage of which is well-known (see Harris 1961). *Cladophlebis harrisii* (Pl. 2, fig. 1) is quite common throughout the whole Hasty Bank section (section S2, see Hill 1974) where *Osmundopsis hillii* has been found. No other fern in which the fertile foliage is unknown occurs in this section; therefore, Dr Hill (pers. comm.) and I are of the opinion that *O. hillii* is the fertile foliage of *Cladophlebis harrisii.*

Osmundopsis sturii (Raciborski) Harris

Plate 2, figures 2–4; Plate 3, figures 1–3; Plate 4, figures 2–5; Text-figure 1

Material. Apart from the material from the Cayton Bay Gristhorpe bed described by Harris (1961, 1977), there are three more specimens from this locality that were found by J. D. Lovis, and one from Cloughton Wyke (*Solenites* bed). Moreover, there is a specimen in the collection at Utrecht. All these specimens will be described here.

Description. V.63876a/b is part and counterpart of a 30 mm long fragment (Pl. 2, figs 2, 4). The 0·5 mm wide, longitudinally striated rachis bears subopposite secondary branches that probably represent pinnules. They are 2 (in the apical region) to 3 mm apart (in the more distal region). These 'pinnules' consist of a thin axis covered by numerous sporangia. The sporangia are *c.* 400 μm long and are probably immature; they yielded masses of thin-walled spores that could not be separated. The 'pinnules' are 5–7 mm long and 1–1·5 mm wide.

V.63877/63878 are part and counterpart (Pl. 2, fig. 3) of a 30 mm long fragment showing a small part of a

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EXPLANATION OF PLATE 2

Fig. 1. *Cladophlebis harrisii* van Cittert. V.58754; ×1.

Figs 2–4. *Osmundopsis sturii* (Raciborski) Harris. 2, V.63876a and b; ×1. 3, V.63877 and V.63878; ×2. 4, V.63876a; ×5.

PLATE 2

VAN KONIJNENBURG-VAN CITTERT, *Cladophlebis*, *Osmundopsis* longitudinally striated rachis. There are eight secondary branches or 'pinnules' on one side of the rachis and only one on the other side; they are 3 mm apart, 8–10 mm long and 1·5 mm wide. They consist again of a thin axis covered with numerous pyriform or obovate sporangia, up to 500 μm long. They yielded masses of almost mature spores.

V.63875, from Cloughton Wyke, shows two pinna fragments lying next to each other (Pl. 3, fig. 1) and, slightly apart, an apical pinna fragment that probably belongs to the same frond. If they were originally attached, the total length would have been over 35 mm. The pinna rachises are 0·5–0·7 mm wide and show longitudinal striations. The secondary branches or 'pinnules' arise at a distance of 2·0–3·5 mm and are subopposite. Their maximum length is 10 mm, maximum width 1·5 mm (in the apical part the pinnules are crowded, sometimes even touching each other, and they are smaller). Again they show a thin axis covered with numerous, up to 600 μm long, pyriform sporangia. The sporangia clearly show that the cells of the whole apical region are thickened (Pl. 3, fig. 2). The sporangia yielded numerous, almost mature spores.

V.63934 shows several parallel pinnule fragments almost touching each other. The longest fragment is 8 mm long and 2 mm wide. The thin axes are covered with numerous pyriform sporangia that are 500–600 μm long and 300–400 μm wide. The sporangia yielded numerous spores.

V.63990 is a box with loose sporangia fallen from various specimens. It showed typical sporangia (Pl. 4, fig. 2) and mature spores, sometimes with a margo (thickening along the trilete mark; see Pl. 4, fig. 4).

S.7509 (Pl. 3, fig. 3) shows a 20 mm long pinna fragment, axis 1 mm wide, consisting of seven pairs of opposite, well-separated (*c.* 2 mm apart) 'pinnules' that are up to 10 mm long, and 1·5 mm wide The thin axis of the pinnules is covered with numerous sporangia that yielded good spores. These spores and the ones from Harris' (1961) material were described in detail by van Konijnenburg-van Cittert (1978). The spores recovered from the other specimens described here agree in all aspects with this description, but show a slightly greater size, which may be due to the fact that only completely mature grains have been measured in this study.

Spores trilete, more or less spherical in equatorial outline. Laesurae distinct, narrow, sometimes bordered by a thin margo. Exine about 1·5 μm thick, covered with fused granules forming an irregulate pattern.

Mean spore diameter *c.* 48 μm (extremes measured 42–54 μm). Mean spore diameter in the previous description was 42 μm (extremes 32–52 μm). This difference is mainly caused by the absence of small spores in the new material. For spore illustrations, see Plate 4, figures 3–5 and Text-figure 1.

Remarks. The new material described here agrees in all details with the two specimens described by Harris (1961) and discussed by Harris (1977). There is no doubt about the absence of lamina, so their attribution to *Osmundopsis* is certain. Harris (1961, 1977) stated that, although there are large differences in preservation between the Yorkshire specimens and the original Polish material, there are no fundamental differences between them. Therefore, he attributed his material to *O. sturii.* Similar material from Iran was described by Kilpper (1964) as *O.* cf. *plectrophora.* Recent studies (Schweitzer *et al.* in press) have demonstrated, however, that this material is indistinguishable from *O. sturii.*

Sterile foliage. Another problem is the sterile foliage that belonged to this fertile material. It appears that none of the *Todites* or *Cladophlebis* species from the Gristhorpe bed at Cayton Bay (and from the *Solenites* bed at Cloughton Wyke) is available as sterile foliage; only fertile material is known. Lovis collected some sterile foliage from Cayton Bay that he thought might have belonged to *Osmundopsis* (Pl. 5, figs 1–4). However, its venation (Pl. 5, figs 2–3: Text-fig. 2) is unlike that seen in either *Cladophlebis* or *Todites*, and resembles much more the venation of the dicksoniaceous genus *Eboracia.* Indeed, when studying the material in detail, it proved that, although some of the specimens were considerably larger than normal *Eboracia lobifolia*, others showed all the characteristic features of that species, including the forked basal pinnule (Pl. 5, fig. 1). As

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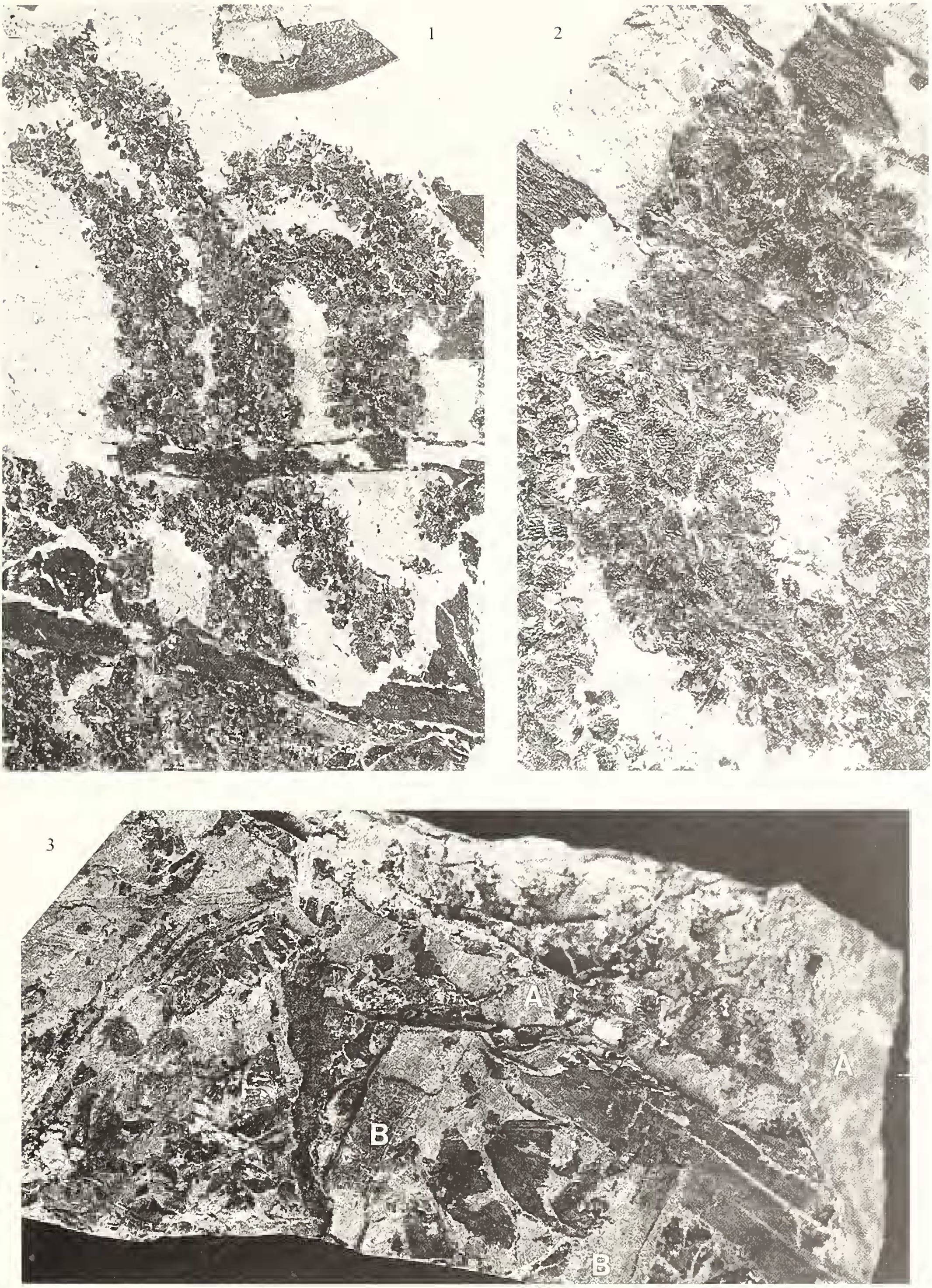
EXPLANATION OF PLATE 3

Figs 1–3. *Osmundopsis sturii* (Raciborski) Harris. 1, V.63875; ×7·5. 2, V.63875, showing thickened apical cells; ×20. 3, S.7509B, *O. sturii* (between A and A), associated with *Cladophlebis denticulata* pinnules (between B and B); ×2·5.

Figs 2–3, photographs courtesy of Prof. Dr H. Kerp.



VAN KONIJNENBURG-VAN CITTERT, *Cladophlebis*, *Osmundopsis* intermediate forms were also present, I think that all this material must be included in *Eboracia lobifolia*. The main difference between the new material and *E. lobifolia* as described by Harris (1961) lies in the pinnule size (up to 11 × 5 mm, see Pl. 5, fig. 2; while Harris gives 9 × 3 mm as the largest size) and the fact that in those large pinnules the base is always contracted on both sides (Pl. 5, figs 2, 4). In *E. lobifolia* the base is usually well constricted on the upper side, and only slightly or not at all on the lower side. Moreover, in the new material the large pinnules are often not lobed apart from the prominent basal lobe on both sides (Pl. 5, figs 3–4). The margin is in these cases only slightly wavy or even almost straight. The prominent basal lobe is supplied by one or more veins that arise from the pinna rachis rather than the midrib. In Harris' description there is only one such vein (twice forked) arising from the pinna rachis while in the new material there are sometimes more veins arising from the pinna rachis (see Text-fig. 2). But, as said above, some of the specimens are typical *Eboracia lobifolia* (Pl. 5, fig. 1), and intermediates are present as well (Pl. 5, figs 3–4).

Van Konijnenburg-van Cittert (1978) mentioned the presence of small sterile *Cladophlebis denticulata* fragments on S.7509 (Pl. 3, fig. 3). The Iranian *Osmundopsis sturii* material is almost certainly linked with *C. denticulata* leaves with relatively small pinnules. On the three Cayton Bay specimens described here, *O. sturii* was the only fossil present, but on the Cloughton Wyke specimen *C. denticulata* was also present. Therefore, it is possible that the artificial form-species *C. denticulata* consists of two natural taxa, one (often with large pinnules) linked with *Todites denticulatus*, and one (with relatively small pinnules) linked with *O. sturii*.

COMPARISONS

Osmundopsis hillii is easily distinguished from *O. sturii* by its smaller 'pinnule' size and the comparatively large distance between the pinnules. The whole pinna has a much looser appearance than in *O. sturii*. This is also caused by the fewer sporangia present in each pinnule. Indeed, in *O. hillii* the tertiary, very short branches (protuberances) are early recognizable and the number of sporangia per protuberance (and thus the number of sporangia per group) is never more than eight, while in *O. sturii* the tertiary branches are almost unrecognizable as they are covered by numerous sporangia. The separate groups of sporangia are easily seen in *O. hillii* (Pl. 1, figs 3, 5) while they cannot be recognized in the Yorkshire *O. sturii* material (in the Iranian material they can sometimes be seen in completely mature specimens). Finally, the sterile foliage attributed to *O. hillii* (i.e. *Cladophlebis harrisii*) is different from any other known *Cladophlebis* species (van Cittert 1966).

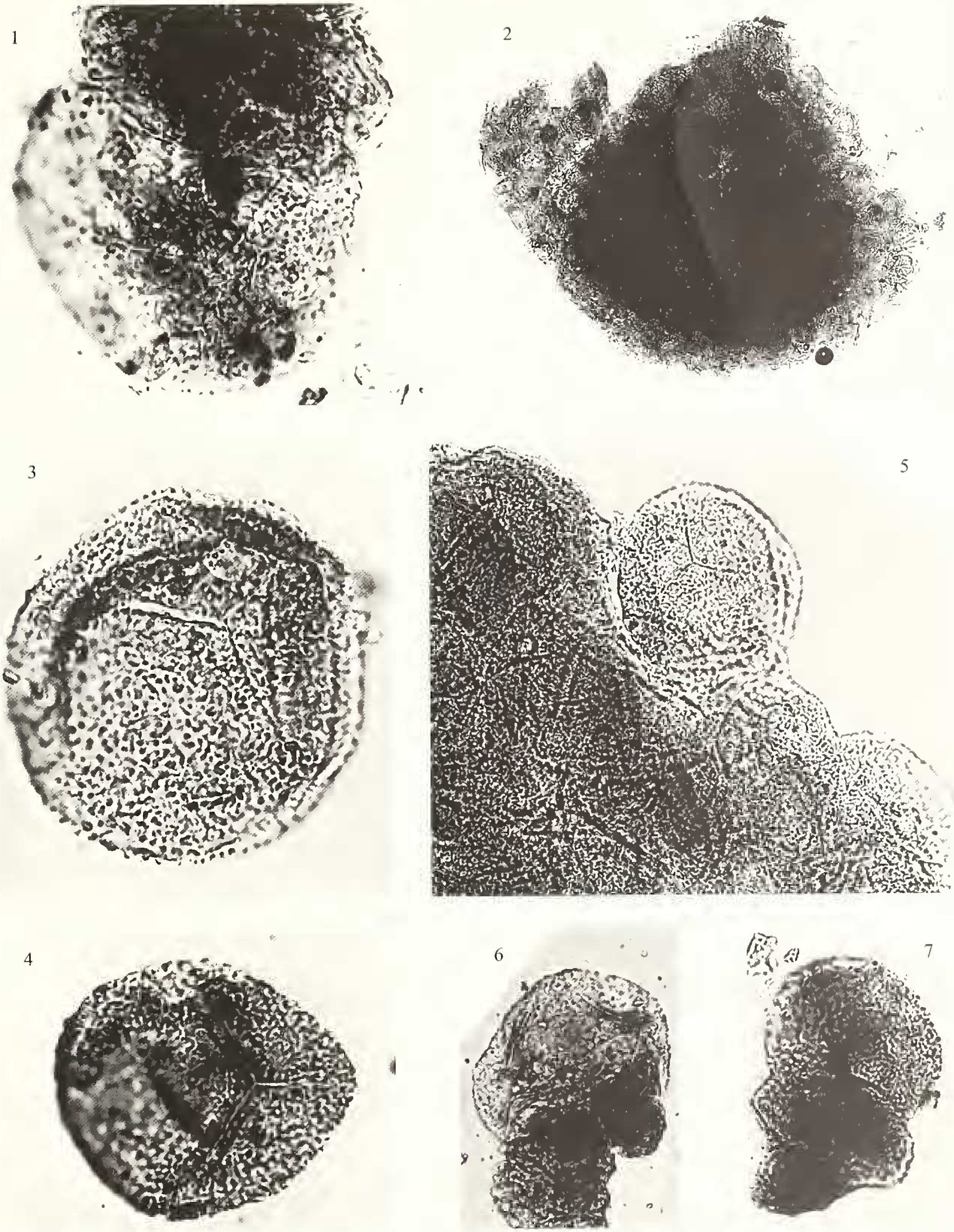
Osmundopsis microcarpa (Raciborski) Harris, from the Liassic of Poland, might have been young and/or apical fragments of *O. sturii* (see Harris 1977). *O. prigorovskii* Krystofovich and Prynada, 1933 may also be similar (Harris 1961). *O. prynadae* Delle, 1967 is also very similar to *O. sturii* and is associated with *Cladophlebis denticulata* leaves. This material (there is only one specimen) might very well be an immature *O. sturii* fragment; the fact that the spores are small (25 μm) and almost smooth may support this view. *Osmundopsis nipponica* Kimura and Tsujii, 1980 is also very similar to *O. sturii*, differing only in slightly less elongated secondary branches and smaller sporangia. It is, however, possible that all these species are real species that differ mainly in their sterile foliage. But as many of these sterile leaves are not yet known, I cannot make a definite statement.

EXPLANATION OF PLATE 4

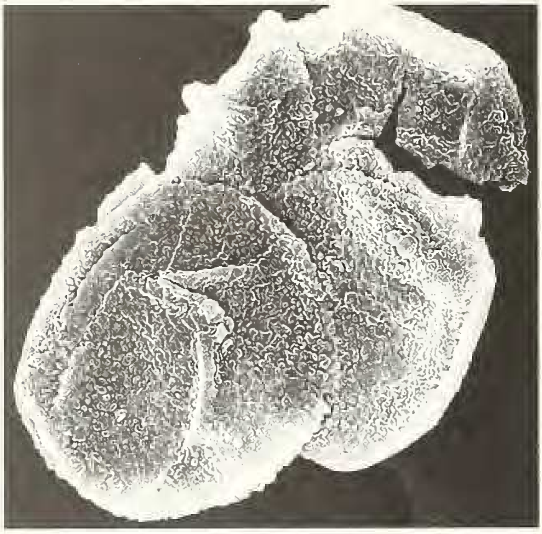
Figs 1, 6–7. *Osmundopsis hillii* sp. nov. spores. 1, V.60945S2; × 1000. 6, from holotype, V.60952S1; × 500. 7, V.60954S2; × 500.

Figs 2–5. *Osmundopsis sturii* (Raciborski) Harris. 2, V.63990, typical sporangium with spores; × 100. 3, LM micrograph of spore from V.63878S2; × 1000. 4, LM micrograph of spore with margo, V.63990S1; × 1000. 5, LM micrograph of group of spores, V.63878S2; × 500.

PLATE 4



VAN KONIJNENBURG-VAN CITTERT, *Osmundopsis*



TEXT-FIG. 1. *Osmundopsis sturii* Raciborski) Harris; SEM photo of spores from S.7509; ×800.

TEXT-FIG. 2. Schematic drawing of the venation in large pinnules of *Eboracia lobifolia*; (Phillips) Thomas; *c.* ×5.

O. plectrophora, from the Liassic of Greenland (Harris 1931), differs from both *O. hillii* and *O. sturii* in its longer stalked sporangial groups and broader sporangia (up to 0·6 mm; while they are only 0·3 mm in *O. hillii* and 0·4 mm in *O. sturii*).

O. scythica Stanislavski, 1971 resembles *O. plectrophora* both in its larger sporangia and in the sterile leaves with a lobed basal pinnule that overlies the rachis. The difference between the two species lies mainly in the venation of the sterile leaves: the secondary veins in *O. scythica* often fork twice, while they fork only once (apart from the basal vein) in *O. plectrophora*. Here again, we see

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EXPLANATION OF PLATE 5

Figs 1–4. *Eboracia lobifolia* (Phillips) Thomas. 1, V.63942a; small leaf fragment with a typical basal pinnule (arrow); ×2. 2, V.63940; large pinnules, showing venation and contracted bases on both sides; ×2·5. 3, V.63939b; two pinnae, pinnules with contracted bases only on the upper sides; ×2·5. 4, V.63935; pinna, typical of the present material; ×1.

PLATE 5

VAN KONIJNENBURG-VAN CITTERT, *Eboracia*

TABLE 1. Comparison of *Osmundopsis* species

Species	*O. hillii*	*O. sturii*	*O. plectrophora*	Antarctic *Osmundopsis*
Distance between 'pinnules'	3–5 mm	2–3 mm	3 mm	2 mm
Length of fertile 'pinnules'	Up to 8 mm	Up to 10 mm	Up to 20 mm	Up to 3 mm
Number of sporangia/cluster	Up to 8	Up to *c*. 20	Up to *c*. 12	?
Maximum sporangium size	500 × 300 μm	600 × 400 μm	800 × 500 μm	?
Mean spore diameter	42 μm	48 μm	50 μm	?

the main difference between two *Osmundopsis* species in the sterile leaf and not in the fertile part.

Taylor *et al*. (1990) described some sterile and fertile osmundaceous material from the Upper Triassic of Antarctica, without formally naming it. The fertile material consists of reduced, modified pinnae *c*. 10 mm long, arising suboppositely at *c*. 2 mm from each other from a *c*. 5 mm wide rachis. Each fertile pinna is a non-laminated unit bearing side branches (only up to 3 mm long), about 2 mm from each other with a thin rachis covered with tightly compacted clusters of sporangia. No details of the sporangia or spores have been described or are visible from the illustrations.

Osmundopsis hillii, *O. sturii*, *O. plectrophora* and the Antarctic material are compared in Table 1.

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